CLIMATIC DESIGN AND DATA

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This booklet forms part of the kit
ENERGY CONSERVATION THROUGH LAND USE PLANNING

The kit is a collection of materials designed to help those involved in developing and making decisions on energy sensitive subdivisions.

Each piece was designed for a particular purpose:

Planning and Development Strategies for Energy Conservation provides a general **overview** of energy conservation as it relates to land use planning.

Energy Sensitive Subdivision Design and Evaluation provides a **process** for identifying and utilizing opportunities for energy conservation in subdivision design.

Climatic Design and Data provides more detailed technical **information** and relevant data.

Copies of this kit may be obtained from:

Inter Agency Planning Branch
Planning Services Division
Alberta Municipal Affairs

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CLIMATIC DESIGN AND DATA

Booklet #3 in the series

Energy Conservation through Land Use Planning

Inter Agency Planning Branch
Planning Services Division
Alberta Municipal Affairs
September, 1985

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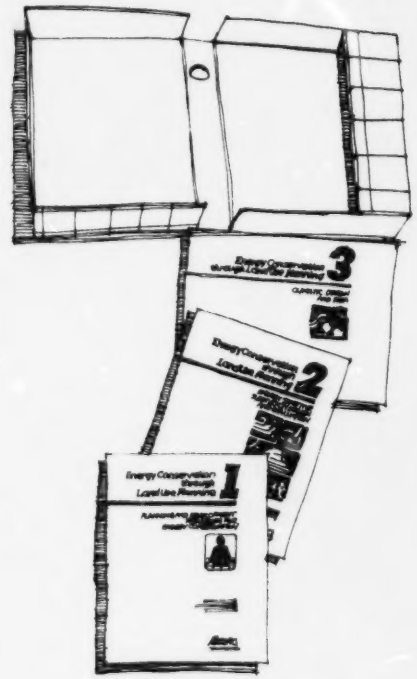
INTRODUCTION

During the past several years, a growing number of Alberta builders have emerged as providers of energy efficient homes. This trend has been stimulated by increasing consumer interest and government grant and education programs available to the Province's homebuilders.

As the experience of builders of energy efficient housing has broadened, so has recognition that the correct site conditions must be present in order for the full potential of energy savings to be realized. As a result, builders are seeking out sites that have been planned with energy conservation opportunities.

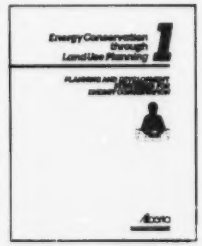
This package of information — **ENERGY CONSERVATION THROUGH LAND USE PLANNING** — was developed in response to the need for technical guidance in the design and evaluation of building sites, so as to make them as sensitive to energy conservation opportunities as possible. The information has been packaged in a "kit" format to enable a variety of users to find the materials appropriate to their understanding and interest. Thus there are materials for elected officials (booklet #1: Planning and Development Strategies for Energy Conservation); subdivision designers and evaluators (booklet #2: Energy Sensitive Subdivision Design and Evaluation); and for those requiring detailed technical information and Alberta data (booklet #3: Climatic Design and Data). It is hoped that by presenting these materials in one package, the user will be better able to find the level of information appropriate to the decision being considered.



KIT COMPONENTS

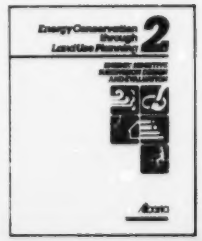
The Kit **ENERGY CONSERVATION THROUGH LAND USE PLANNING** consists of three components:

1. Planning and Development Strategies for Energy Conservation



The booklet **Planning and Development Strategies for Energy Conservation** provides a general overview of energy conservation as it relates to land use planning. Its purpose is to give municipal planners, administrators, elected officials and the public a broad understanding of the many opportunities for saving energy present in land use planning; specifically in the area of new subdivision and development.

2. Energy Sensitive Subdivision Design and Evaluation



The handbook **Energy Sensitive Subdivision Design and Evaluation** forms the heart of the kit. The handbook asks a series of carefully sequenced questions to aid the user in identifying opportunity on a site for creating conditions favourable to achieving energy efficient development; or to identify problem areas that should be addressed.

HOW THIS BOOKLET IS ORGANIZED

This booklet --- Climatic Design and Data --- provides more detailed technical information on energy efficiency through site design, the effects of good site design on building energy use and data related to specific design measures. The booklet contains four major sections:

1. **The Effects of Climate upon Human Comfort**
2. **Energy Use and the Range of Residential Housing Types**
3. **Characteristics of Solar Radiation**
4. **Vegetation for Wind Management and Solar Exposure**

The Appendix sections provide climatic data for eleven weather stations in the province together with a method for graphically displaying how this climate data interacts with site-specific characteristics. A step-by-step procedure for developing a topo-climatic map is provided.

THE EFFECTS OF CLIMATE UPON HUMAN COMFORT

The physical environment consists of many complex relationships structured by climate, light, sound, space, perception and psychological disposition. They all act directly on the human body which can either absorb them or try to counteract their effects. Man strives for the point at which a minimum expenditure of energy is needed to adjust himself to his environment. The sum total of conditions under which equilibrium is achieved can be defined as the "comfort zone".

The comfort zone has no real boundary but rather is constituted of levels of increasing discomfort. In addition, men and women express preferences for different conditions. These preferences vary further by age, activity, season and geographic region.

The major elements of climate which affect human comfort are air temperature, radiation, air movement and humidity. Typical North American comfort condition lie between 69° and 80° F and between 30 and 65% relative humidity. It is the function of shelter to modify the natural environment to approach conditions of livability.

Human beings exchange heat with their surroundings through three major processes: radiation, conduction, convection.

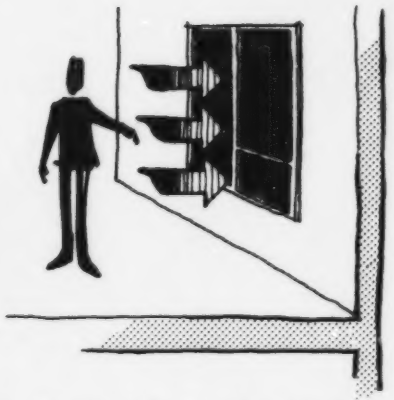
RADIATION

Radiation and its converse absorption is the transfer of heat from a warm body to a cooler one. When sunlight strikes a surface, it can be reflected, transmitted or absorbed, depending on the texture, color and clarity of the surface. All completely opaque surfaces both reflect and absorb radiation but they do so in different ways. For example, a rough surface such as stucco reflects uniformly at an angle equal to the angle of incidence. A clear surface, such as a window glass, allows nearly all radiation to pass through it with comparatively little reflection or absorption and without deflecting it from its parallel lines of travel.

Measuring the temperatures of a white surface and a black surface exposed to direct sunlight is the simplest demonstration of the conversion of solar energy to heat energy. As solar energy is absorbed at the surface of a material it accelerates the movement of the molecules in the material. Molecular movement is measured in terms of heat, with the greater the movement, the greater the heat.

Radiation often occurs from occupants to wall and window surfaces. It is estimated that radiation accounts for about 2/5 of the heat loss from the body.

The degree and efficiency to which heat exchange occurs depends upon the medium through which this takes place. Radiant heat transfer depends upon the radiation and absorption capability of the surface. The reflectivity or "albedo" of a surface may vary from 1.0 which is perfect reflectivity of everything which shines on it without receiving or retaining any of the heat or light and reflecting none of it.



Human body loses heat to cold surfaces by radiation.

The reflecting rate for rough textured, wet or dark colored surfaces tend to be lower than those of lighter, smoother or drier surfaces. To ensure greater absorption and retention of solar radiation by various paving and construction surfaces, darker colors and rougher textures should be used.

In order to reflect all incoming solar radiation, smooth, light coloured paving, wall and construction surfaces can be utilized. For example, on the cool north side of a building a light colored fence or wall or light colored smooth paving may help to reflect sunlight into an area and would therefore make it lighter and warmer than would otherwise be the case.

CONDUCTION

As a material continues to absorb radiation and molecular movement continues to accelerate, the heat energy is redistributed. This is accomplished when neighboring molecules vibrating as different rates bump into each other. Those vibrating at a faster rate pass some of their energy to those vibrating at a slower rate.

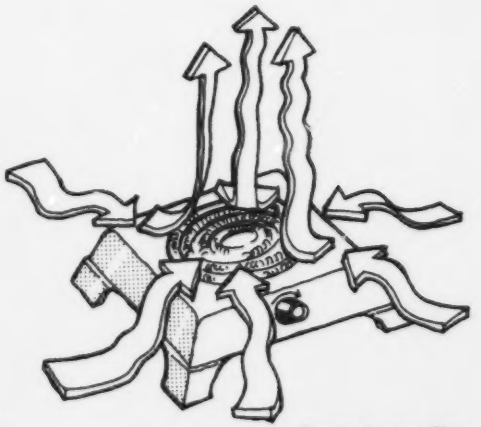
In this way, heat is conducted away from the source of energy as the material seeks to distribute the energy evenly throughout its mass. Generally, gases are poor conductors and less dense materials that contain tiny pockets of air conduct heat at a much slower rate.

Conductive heat transfer

CONVECTION

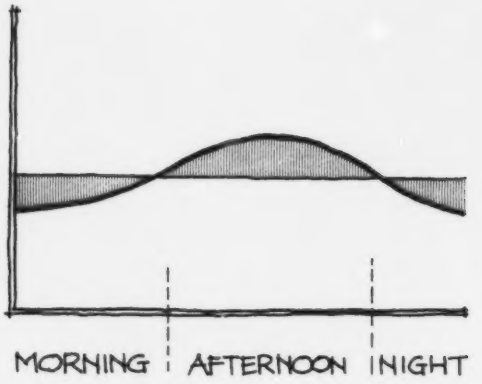
Heat is transferred from a solid material to a fluid, such as air by the addition of heat energy to the fluid in the form of infra-red radiation. Since fluids can move across a surface, molecules in the fluid can move away from or across a solid source of heat after the molecules have been heated. This process is called **natural** convection when unaided by mechanical energy and **forced** convection if the process is aided by a pump or fan.

As air is heated it tends to become less dense and therefore lighter than the surrounding unheated air. Being lighter, the heated molecules rise at a rate determined by the amount of heat applied. Boiling water is an example. Heated molecules near the burner rise quickly to the surface and give the contents of a pot a rolling appearance. Steam generated by the process is simply water molecules whose vibration rate is violent enough to allow them to break free of the water surface. Conduction and convection are processes by which solar energy can be both transported and stored. Convection is the movement of air resulting from a change in temperature. The air film close to a surface gains heat by conduction and as its density falls, it is replaced by denser and cooler air which in turn is warmed and displaced.



Convective heat flow

It is when conditions of temperature and humidity fall outside the comfort zone that energy consuming equipment is used. For example, within a conventionally built home's interior, temperature tends to fluctuate widely as a result of high rates of infiltration and resultant air movement. This often causes heating devices to cycle on and off frequently. Continuous cycling is highly energy inefficient for motors or pumps, that would work best at moderate continuous rates.



Interior temperature fluctuation

ENERGY USE AND THE RANGE OF RESIDENTIAL HOUSING TYPES

Outdoor climate conditions can significantly affect the perception of comfort by building occupants and the resultant need for relying upon energy consuming equipment to heat, cool, ventilate or humidify interior spaces.

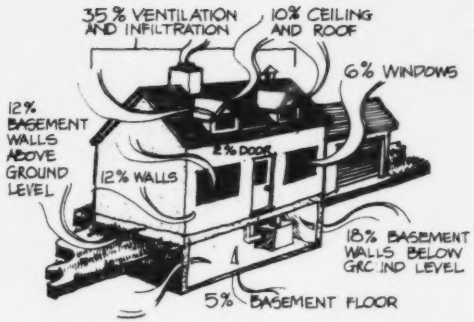
The potential benefits from site planning approaches that moderate negative climate conditions and preserve opportunities, can be greater for conventionally built homes in Alberta where the impact of solar gain and infiltration can be more significant than in structures purposefully designed to be energy efficient.

Consideration of measures to preserve or create opportunities for energy efficiency through site design should be based upon an understanding of the types of homes and other buildings that can be expected to be built in Alberta in the near future. The particular qualities of a range of housing types from conventional to those using active solar approaches, is discussed in the following sections.

CONVENTIONAL HOUSING

Conventional housing is frequently designed and located on a site "blind" to solar opportunities and damaging effects from winter winds. The orientation of glazed surfaces and the position of doors, windows and other openings are most often governed by a chance response to lot size and shape, standard building layout and other factors. However, it is precisely these poorly insulated buildings that could benefit most from site measures aimed at managing cold winds and temperatures and building orientation that can take advantage from solar gain.

For example, if all the cracks and holes in a typical house were located within one area, it would be roughly equivalent to a two square foot hole from which warm air would escape. The average home may experience a total air change every two hours. This can account for approximately 30 to 40 percent of the total heat loss. This rate of heat loss through cracks and through windows can be significantly decreased by protection from winter winds. It has been estimated that a reduction of wind speed from 32 to 8 km/hr. can result in a fuel saving in a typical single family home of from 20 to 30 percent.



Heat loss from a conventional house

SUPER ENERGY EFFICIENT HOUSING

Since early 1983, under the Super Energy-Efficient Home Program, administered by Energy, Mines and Resources Canada in co-operation with the Housing and Urban Development Association of Canada, "super energy efficient" homes have been built throughout Canada. These homes are designed to provide as much as a 60 to 80 percent reduction in space heating energy use, with potential reductions in hot water energy use of 50%. As of 1983, 33 of these units have been constructed in Alberta to these "R-2000" standards of energy efficiency. Comparable characteristics for energy conserving homes have also been adopted by the Canadian Electrical Association, in its "Super Double E Program", for consideration by Alberta's electrical utilities.

The characteristics prescribed for these homes represent the state-of-the-art in energy efficient home designs that could be offered by the Province's home builders. Variations on the principles of the R-2000 home are presently being offered to Alberta's new home buyers.

These units incorporate high levels of insulation, airtight construction incorporating heat recovery ventilation systems, improved double to triple glazed windows, and energy efficient appliances and heating equipment. To ensure a significant reduction in energy costs, the R-2000 Home is wrapped on the inside with a continuous airtight vapor barrier. The barrier is sealed to eliminate drafts, and prevent moisture from entering the walls and to control the rate of air exchange. Also, doors and windows are sealed tight with weather stripping and where possible drafts created by open doors are minimized by the use of air-lock vestibules.

Insulation in its various forms is the single most important factor in retarding the flow of heat in buildings. R-2000 homes have very high levels of insulation in basements, walls and ceilings. The walls of the R-2000 home are often twice as thick as typical homes in order to accommodate large quantities of insulation. High levels of insulation are also used in the attic and on the basement walls. Overall, the R-2000 home contains two to three times more insulation than the average new home.

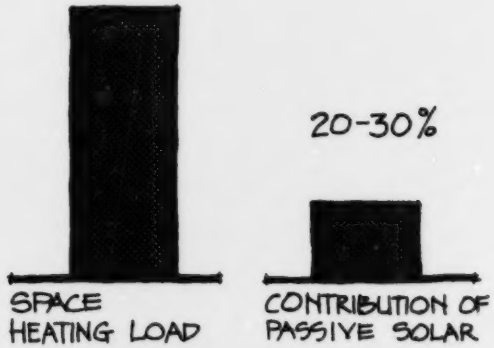
To further contribute to low fuel consumption, and ensure adequate air quality, R-2000 homes incorporate air-to-air heat exchanges, which preheat incoming fresh air by transferring heat from outgoing stale air.

The windows of the R-2000 home are double or even triple glazed in order to take maximum benefit from solar gain.

PASSIVE SOLAR HEATING

Typically a building is designed with a heating and cooling system, (such as a forced air furnace and ducts) separately planned for it. In passive design, the system is the structure itself. Windows, walls, floors, and roof are designed to play some part in collecting, storing, releasing and distributing heat when the opportunity to do so presents itself. That is not to say that passive solar designs eliminate the need for a back-up standard heating system. On the other hand, a cleverly designed passive solar structure can greatly reduce the size of the conventional system and reduce the amount of electricity or gas needed to maintain comfortable indoor temperatures.

Although consistent and widespread monitoring of buildings designed with passive solar heating systems in Alberta is not available, analysis of passive homes built in Saskatchewan together with discussions with Alberta solar design firms indicate that such systems could provide 20-30% of the annual space heating load for a single family detached home.



Passive solar contribution to space heating

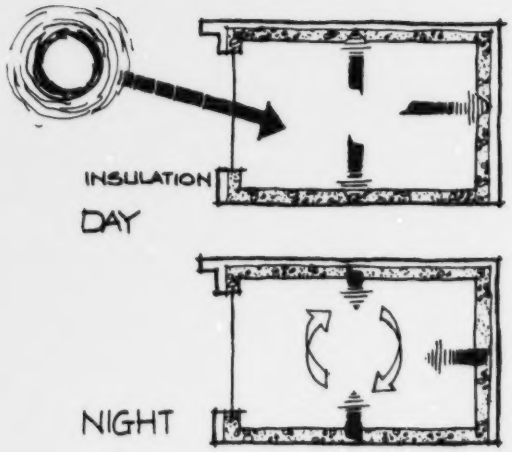
Two basic elements must be present in all passive solar heating designs:

1. A south facing exposure of clear material, such as glass or plastic to allow solar energy to enter; and
2. A mass of material to absorb and store the heat for later use.

The following are descriptions of the general design approaches for passive solar space heating.

Direct Gain

The simplest of the passive solar heating approaches is termed "direct gain". In this approach sunlight is admitted to the space by south facing glass and virtually all of it is converted to thermal energy. The walls and floors in this kind of design are used as "thermal storage masses" either by intercepting radiation directly or by absorbing reflected or reradiated energy. As long as the temperature remains high in the interior space the storage masses will continue to conduct heat to their interior. At night, when outside temperatures begin to drop and the interior space cools, the heat flow into the storage masses is reversed and heat is given up to the interior space in order to maintain a comfortable temperature during the night.

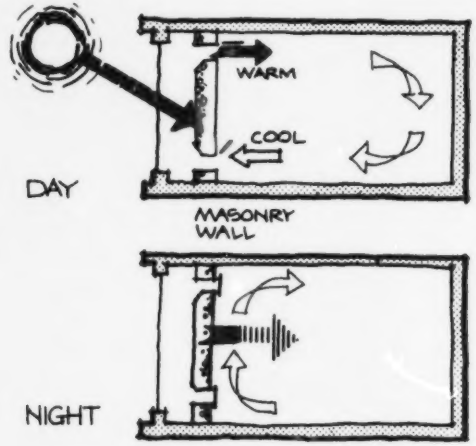


Direct gain design

Indirect Gain

Another passive solar design approach uses the two basic elements of collection and storage of heat and also takes advantage of the convection process. This is referred to as indirect gain. In these designs, the storage mass is placed between the interior space and the sun so that no heating is done by direct sunlight. Instead a dark colored storage mass is placed just outside a south facing glazed collection area. Sunlight enters through the glass and is absorbed on the surface of the storage mass and is eventually conducted through the mass to the inside space.

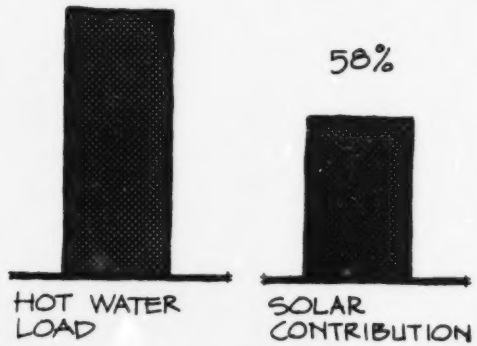
A popular interpretation of indirect gain involves a south facing greenhouse attached to a storage wall exposed to the direct rays of the sun. The walls absorb heat at the same time the interior space of the greenhouse is being heated. The greenhouse then, is heated by direct gain while the living space is heated by indirect gain.



Indirect gain design

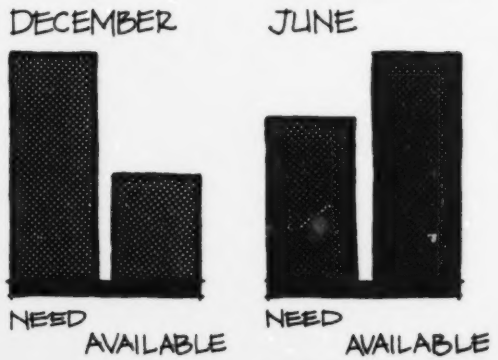
ACTIVE SOLAR APPLICATIONS

Domestic water heating for single family homes is one of the simplest applications for solar energy in Alberta after passive solar heating, and one which involves a relatively low capital cost. It represents a more efficient use of collection capacity than solar space heating since hot water demand remains fairly constant throughout the year. In a study prepared for Alberta Energy and Natural Resources, "Prospects for solar and wind energy utilization in Alberta", the percentage of the total annual hot water needs for a typical Edmonton home was estimated for various sizes of flat plate collectors. For a collector area of 100 square feet, about 58% of annual water heating needs could be provided by solar and 22% of the load during the worst month. There is little point in increasing the solar contribution beyond 75% since it will be necessary in any case to use supplemental gas or electric heating to raise the water temperature from the level that can be obtained with solar heating during the winter to the temperature of 52° to 60°C that is needed. Solar is essentially used to pre-heat water for entry into a standard electric or gas heater.



Solar hot water contribution

This same study concluded that solar water heating in multiple family housing constitutes one of the more economically attractive applications of solar energy. Typical simple types of flat plate collectors are able to heat water or air to temperatures that are directly suitable for space heating. One of the problems is the mismatch between the availability of solar energy and the demand for space heating. For example, the amount of solar energy that can be collected during December and January in Edmonton is only about one-third the annual average. On the other hand, the space heating load during these months is approximately twice the annual average. As a consequence, a system that is designed to supply the heating requirements of a building on an annual average provides only one-sixth of the heat required during December, but would be capable of supplying 3 or 4 times the heating load during the summer months.

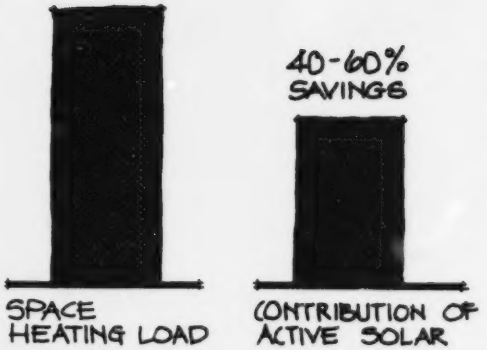


Mismatch in seasonal solar contribution

This mismatch can be tempered partially by combining domestic solar water heating with space heating. The addition of a constant water heating load to the variable space heating load typically increases the utilization of solar collection capacity by about 10% in a single family residence.

Although the proportion of the heating load supplied by a given collector area varies considerably with latitude, the actual amount of solar radiation utilized is relatively constant throughout Alberta. The percentage of the annual space heating loads that can be supplied by 500 sq. ft. of collector ranges from 40% at Fort Smith to 70% in Suffield. During the worst month a contribution of less than 1% has been estimated for Fort Smith and 23% for Suffield.

These percentages would be typical of homes built in the province prior to 1975 with associated low levels of insulation. It is more likely that housing designed for solar applications would be well insulated. This would make it possible to supply a higher proportion of the heating load with the same collector area. The proportion of the heating load supplied by a 500 sq. ft. of collector area could be increased from 43% in an average house to 60% in a well insulated house.



Contribution of active solar to space heating needs

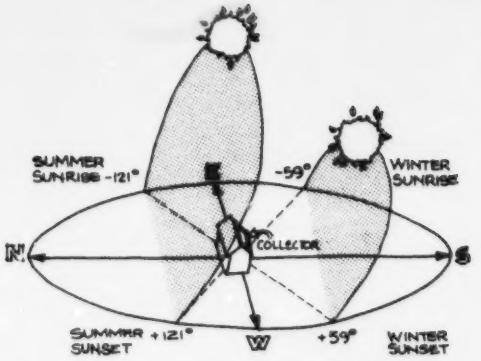
CHARACTERISTICS OF SOLAR RADIATION

DEFINING THE POSITION OF THE SUN

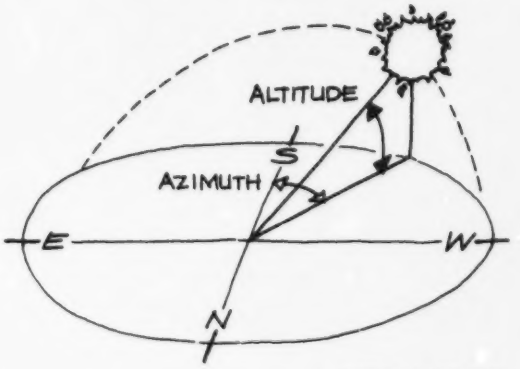
Each day the sun travels in a circular path across the sky, reaching its highest point at noon. As winter proceeds into spring and summer, this circular path moves higher in the sky. The sun rises earlier in the day and sets later.

Although the sun's position in the sky changes from minute to minute and season to season, its position at any one time can be determined by using two measurements, **altitude** and **azimuth**. Altitude is the distance, measured in degrees, between the sun and the horizon, 0° at sunrise and sunset, and up to a maximum of 90° at noon. Azimuth is the distance, measured in degrees, of the sun relative to due south. It is expressed as a negative value to the east and as a positive value to the west. The sun's azimuth extends further in the summer than in winter because the sun rises and sets farther north in summer.

The intensity of solar energy reaching a particular point on the earth's surface is controlled by the latitude, the time of day or year, and the amount of atmospheric absorption and scattering.



Winter and Summer Sun paths



Azimuth and Altitude

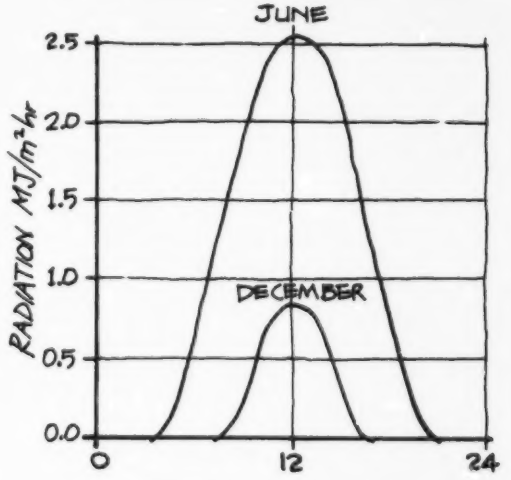
THE EFFECTS OF THE TIME OF DAY UPON SOLAR RADIATION INTENSITY

The sun is less intense in the morning and afternoon hours because it is at an oblique angle to the earth's surface. This also accounts for the lesser amount of solar radiation available in winter, when the apparent position of the sun in the sky is lowered as a result of the earth's tilt.

The solar radiation intensity varies from zero at night to a mid-day maximum which may be 2½ to 6 times the daily average. A characteristic of solar radiation in high latitude regions such as Alberta, is the seasonal difference in the number of hours per day during which useful amounts of solar energy can be recovered. For example, in Edmonton 75% of the daily total is received in only 4 hours during December, whereas significant amounts of energy are received over 14 hours in June.

THE EFFECTS OF THE SEASON UPON SOLAR RADIATION INTENSITY

In Alberta, there are extreme differences in average daily radiation between summer and winter. For example in the northern extremities of the province, the daily average radiation on a horizontal surface during the highest month is approximately 22 times that available during the lowest month. (data extrapolated from Fort Smith, NWT weather station)



Diurnal Variation of Solar Radiation Intensity on horizontal surface

THE EFFECTS OF ATMOSPHERIC CONDITIONS UPON SOLAR RADIATION INTENSITY

The intensity of solar radiation reaching a collector surface may be considerably reduced by the presence of cloud cover, fog and precipitation and to a lesser extent by high relative humidities and atmospheric pollution. These factors vary significantly from one part of the country to another and account for the fact that most Alberta locations receive more solar radiation per year than Toronto, despite the higher latitude. Departures from the normal annual cycle are relatively small in Alberta, reflecting the infrequency of long periods of heavy cloud cover.

Considerably large variations are experienced over a time scale of a few days as a result of the typical weather pattern in which periods of one or more days of cloud or precipitation with limited solar radiation are followed by longer clear periods with slightly above-average radiation.

FACTORS AFFECTING AIR TEMPERATURE

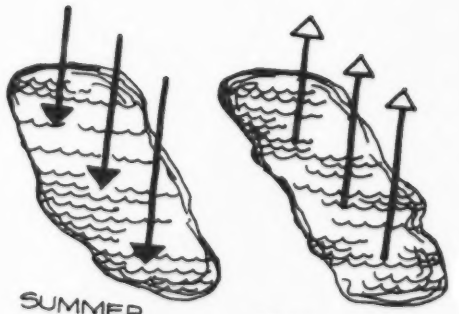
The following, in addition to wind velocity, have a major effect upon air temperatures close to ground level.

Topography

Cool air tends to be denser and will therefore flow downward displacing warmer air at the bottom of a slope. This can result in significant decreases in temperature at the top of a plateau and at the lowest point on a slope. Differences in temperature as great as 6 to 10°F have been determined as a result of this effect.

Water Bodies

Bodies of water, such as lakes and retention ponds function as thermal reservoirs, storing heat during the summer months and releasing it slowly during the cooler times of the year. They therefore can lessen summer maximum temperatures, and serve to raise winter temperatures within their vicinity. In addition to these seasonal effects they can influence temperatures on a daily basis by maintaining relatively constant day and night temperatures when compared to adjacent land areas.



Water bodies and seasonal temperature variation

Vegetation

Forest cover reduces air temperature both by shading the ground beneath it and also by the evaporative cooling associated with transpiration. The results of research has indicated that 60 - 70 per cent vegetative cover of urban areas can influence temperature variations.

The temperature of an area may be reduced by plants, even if they are not tall enough to give shade. Plants and grassy covers reduce temperatures by the scattering of light and radiation and the absorption of solar radiation. Temperatures over grassy surfaces on sunny summer days are about 10° to 14°F cooler than those of exposed soil.

PROVIDING FOR SOLAR EXPOSURE

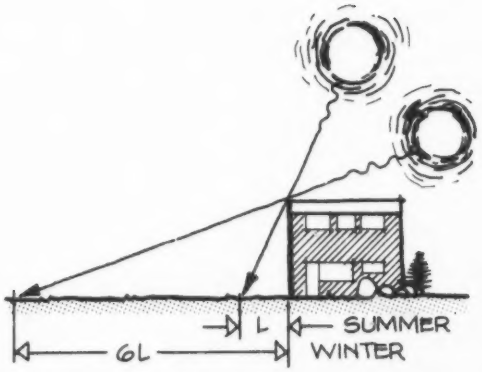
Planning for solar exposure requires consideration of two major factors. The understanding of the **availability** of sunlight and the definition of the **extent** of shading on the site. Solar exposure can be influenced by natural characteristics, atmospheric conditions or by obstructions such as trees or buildings.

Less solar energy is available in northern latitudes, like Alberta, because of the earth's curved surface. The sun appears lower in the sky and solar radiation is therefore more oblique to the earth's surface.

The length of shadows varies as a function of the sun's position and topography.

The Effects of the Time of Year Upon Shadow Length

On December 21st, the "winter solstice", shadows are the longest of any day during the year, with the sun reaching a maximum altitude of approximately 16° - 18°. For example, at 52° 5' north latitude (between Calgary and Red Deer) shadows cast on December 21st, the winter solstice, are over six times as long as those occurring on July 21st, the summer solstice.



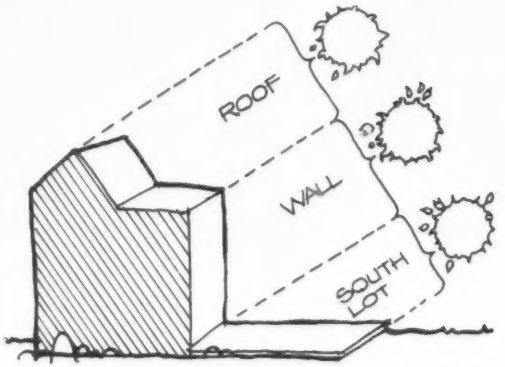
Comparison of winter to summer shadow lengths

Levels of Solar Access Protection

The most probable locations for solar collection surfaces for active or passive applications are on the south wall, or roof top, including clerestory windows.

Roof top locations would be more appropriate for active applications for domestic solar water and space heating. South wall locations are those most often required for passive space heating applications.

It is far more of a constraint to ensure solar exposure for the south facade of a building than to provide such access only to a roof surface which may be located from ten to 15 feet above the finished grade.

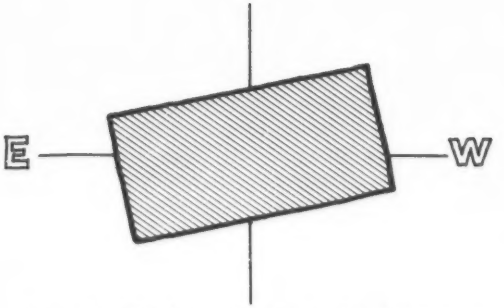


Levels of solar access protection

Building Orientation and Solar Gain

The most direct way of using the sun's energy is to let it penetrate directly through the roof, walls and windows to provide useful heat. Solar radiation strikes differently oriented surfaces with varying intensity, a building will benefit if its walls and roofs are oriented to receive this heat in the winter and shed it in the summer.

Optimal orientations have been suggested from the consideration of how solar radiation and outdoor air temperatures act together to influence the overall heat gain through the surfaces of a building. Because the outdoor air temperatures are lower in the morning and peak in the mid-afternoon, a house should be oriented somewhat east of due south in order to take advantage of the early morning sun when heat is most needed. In the summer, the principal heat gain comes in the afternoon, from the west and southwest, so that the building should face away from this direction to minimize the solar heat gain. In Alberta orientations of 12° to 15° east of south should be considered as optimum.



Optimal building form and orientation for solar exposure

Building Shape and Solar Gain

A building can also benefit in solar gain as a result of different ratios of its length to its width to its height. The ideal shape loses the minimum amount of heat and gains the maximum amount of insolation in the winter, doing the reverse in the summer. South sides of houses receive nearly twice as much solar radiation in winter as in summer. East and west sides receive 2½ times more in summer than they do in winter. The optimum shape for Alberta is a form elongated along the east west direction. The least efficient shape is an elongated form along the north-south axis.

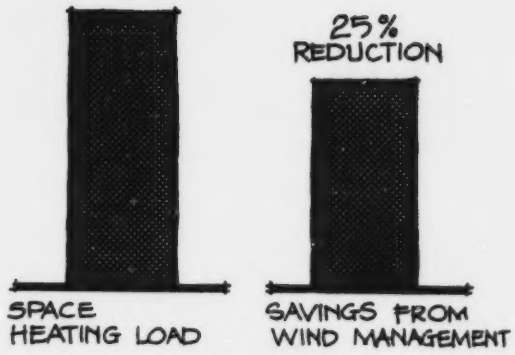
VEGETATION FOR WIND MANAGEMENT AND SOLAR EXPOSURE

CHARACTERISTICS AND EFFECTS OF COLD WINDS

The pattern of wind movement is complex with structures, variegated topography and vegetation causing turbulence. Available wind energies at various locations in Alberta span almost as wide a range as stations in the settled areas of the country. Wind energy available at Rocky Mountain House is lower than anywhere in Canada, apart from the interior valleys of British Columbia, while the available wind energy in southern Alberta is comparable to that in much of the Maritimes.

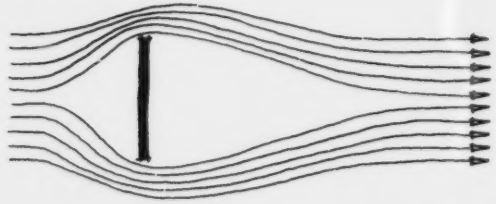
The placement of walls, windows, openings and open spaces relative to the direction of predominant winter or summer winds can significantly affect space heating and cooling needs. For example: an average-sized new house contains about half a ton of air. Typically every two hours, this entire volume of inside conditioned air is replaced by cooler air from outside. The entrance of this cooler air displaces the warm air film increasing convective heat losses. About 60% of air leakage occurs through spaces at connections between foundation and floor, electrical and plumbing penetrations and 20% through windows and doors.

Heat loss from infiltration and reduction in the still air film which surrounds outside walls and windows varies markedly as a function of exposure to wind and its velocity. It has been estimated that a reduction of wind speed from 32 to 8 km/hr. can result in a fuel saving of up to 25 percent. A computer simulation study prepared for the Ontario Ministry of Housing and Municipal Affairs estimated energy savings of 19 per cent for a reduction in wind velocity from 24 to 9.6 km/hr.



Fuel savings from wind velocity reduction

Unhindered moving wind generally flows in parallel layers. Whenever the wind flows over a streamlined or rough surface the boundary layer of air generally speeds up creating a low pressure area between the boundary layer and the surface of the material. When a barrier is introduced into an air stream, the wind responds by flowing around or through the barrier, eventually returning to its original flow pattern. The greater the wind velocity, the greater the pressure differential on the leeward side of the barrier and the quicker the wind returns to its original flow patterns lessening the protected areas to the leeside of the barrier.



Air flow around a blunt object

The negative effects that can result from winter winds can be lessened by the purposeful use of land forms, building mass, fences, walls and vegetation as windbreaks.

VEGETATION AS WINDBREAKS

Vegetation has been commonly used as a media for windbreaks both in rural and urban situations. There are four major characteristics which govern the selection and use of plant material for windbreaks:

1. **Form** - The nature and degree of wind protection provided by a plant is determined to a large extent by its shape. These vary from trees to shrubs, vines and ground covers. Since the particular effect of each type of plant on wind speed is different, they are often used in combination.
2. **Density** - The density of plants varies according to the number, size and form of their leaves and branches.
3. **Seasonal Variation** - The ability of a plant to control wind may vary from season to season. This is particularly the case with deciduous trees and shrubs which lose their foliage during winter months.
4. **Placement** - The optimal location for vegetative shelter belts and the ability of vegetation to form defined zones of protection can vary.

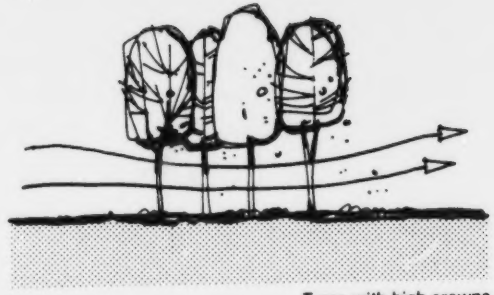
Form

The wind velocity in tree crowns is typically much less than above them and somewhat greater than below them. An understory reduces the wind velocity in the canopy and even more below it. The reduction of actual velocities in the canopy and below it is greater in strong than in light winds. This relative reduction varies little with velocity.

When an air current reaches a stand, part is deflected upward with only a small change in velocity. Another part passes under the crowns with rapidly decreasing velocity, and a third part passes through and among the crowns with very low velocity.

Wind tends to accelerate under belts with higher foliage reducing their value as wind barriers.

A windbreak consisting of a mixture of species is more effective than one of just a single variety. The windbreak must be planned to take advantage of the velocity reduction of evergreens close to ground level and the break-up of streamline flow by deciduous trees toward the top. Openness near the ground may result in wind acceleration.



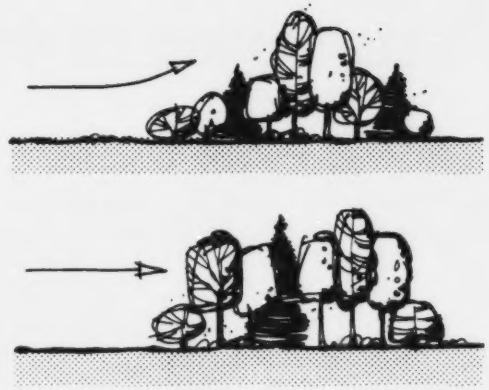
Trees with high crowns

Windbreak with mixture of species

For example, coniferous evergreens that branch to the ground are generally the most effective year-round plants for wind control.

An irregular windbreak, such as the top of a picket fence, is more effective in breaking up a portion of the airstream deflected over it. A mixture of species and series of plants within the windbreak, therefore produces a rough upper surface and is more effective in reducing windspeed. An irregular profile is more effective in reducing edging than more uniform structures. Belts with a gradually rising or "pitched roof" cross section are less effective in halting winds than belts with more or less vertical edges.

The age of foliage has at least a two-fold influence on form: it affects the height and the width of the screen and eventually it diminishes the branches and leaves in the lower-stem storey.



Vertical edges are more effective

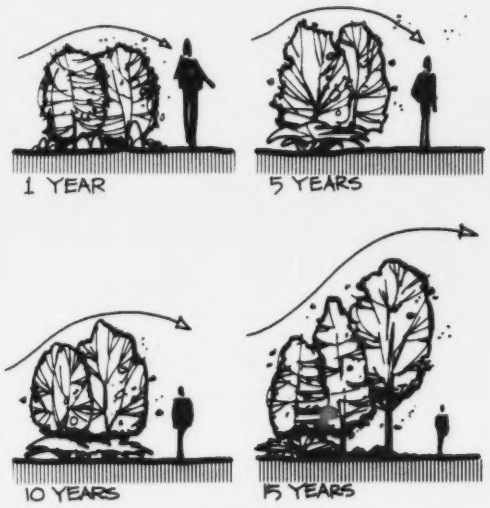
Density

A dense windbreak such as spruce or fir can reduce a 30 mile per hour wind to 10 to 15 miles per hour, while a loose barrier reduces leeward wind velocity up to 60%.

Wind turbulence behind the windbreak increases with the density of the belt. Although it may provide a greater degree of shelter from the wind on the leeward, a dense shelter belt provides a restricted zone of effective shelter downwind. A penetrable shelter has a lower percentage of actual wind reduction near the screen; but the overall effects extend a greater distance beyond. The effect of suction immediately behind the penetrable shelter belt is less than that of a dense shelter belt, and the acceleration of the windbreak to its original force is more gradual behind a penetrable shelter belt.

When a windbreak is completely impenetrable, practically the entire wind force is deflected upward, over the barrier. Pressure behind the barrier is low because the wind does not pass through the barrier causing a suction effect and forcing the air currents above the windbreaks downward.

Partially penetrable windbreaks have different effects on windflow than do dense windbreaks. The more penetrable the windbreak is, the longer the distance behind the windbreak, the more wind velocity is decreased. Some of the wind, in passing through a penetrable windbreak retains a streamlike parallel pattern at a reduced velocity limiting turbulence behind the screen. Studies have shown that a moderately dense foliage belt gives the best average wind speed reduction.



Windbreak management over time

In a penetrable windbreak, the protective effect is somewhat less next to the barrier than in a very dense windbreak, and is felt at a distance equal to its height with the zone of overall protection more pronounced. When a windbreak changes its form according to wind pressure, when trees bend or sway, the penetrability and vertical structure of it are affected and the zone of reduced velocity is decreased. A row of trees, being somewhat elastic, will change its form according to the prevailing wind speed, thereby affecting the resistance to the wind and the degree of penetrability. The percentage of velocity reduction and the zone of quieter air increases as the wind becomes stronger and the center of the quieter air tends to move farther away from the windbreak or the leeward side.

The optimum density for a shelterbelt is about 50 to 60%. This means that the leaves, branches, twigs and trunks should cover 60% of the frontal area of the belt. With this density, narrow belts will afford as much shelter as wider belts of the same overall penetrability.

Seasonal Variation

Studies have found that in the autumn when the trees lost foliage the reduction percentages of the wind velocity had decreased in places just behind a dense screen. Further away from this screen however, the reduction percentages had increased. In other words, the wind distribution curve, which is typical of a dense screen, had turned into one typical of a screen with lower density. Other work has found that this relative perviousness diminished as the velocity of the wind increased. Its flat horizontal branches act like the slats of a venetian blind by drawing closer to each other as wind increases.

Placement

When any bluff or non-streamlined barrier is introduced into an airflow, a pressure eddy is formed immediately in front of the barrier and a suction eddy is created immediately leeward of the barrier. Beyond the barrier a turbulent wake is created.

Planting on the windward side of a hill or a change in grade provides a shorter zone of protection than does planting on the leeward side of a rise in elevation. The ability of planting to provide wind protection can be increased by using it in conjunction with topographical relief.

Wind flow is modified at a distance from two to five times the height of a barrier, in front of a wind obstruction, and from 10 to 15 times the height leeward of such a barrier. Wind velocity may be reduced by 50% for a distance of from 10 to 29 times the tree height downwind of a shelter belt. Wind speed is also affected within or on the windward side of a windbreak, reduced for a distance of 100 yards on the windward or front side of a 30' high shelter belt.

Sheltering efficiency of a treebelt is reduced when the wind passes over a very rough surface before it strikes the belt.

The zone of wind reduction on the leeward and windward side of a barrier are largely dependent upon the height of the barrier. The taller the trees, the more rows of trees are required for protection since shelter belts become more open. Instead of reducing the wind, avenues of trees open at the bottom increase wind speed as the air stream is forced beneath the tree canopy and through the tree trunks.

Parallel shelter belts, spaced widely apart, have no cumulative effect on reducing wind velocity. However, there will be some cumulative effect in the reduction of wind velocity, when a series of shelter belts are spaced closer than five times their height, or when the distance between two shelter belts is less than three times their height.

VEGETATION AND SOLAR EXPOSURE

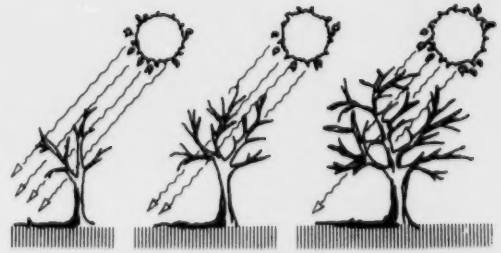
There are two major considerations in planning landscaping to preserve solar exposure: the selection of tree species and their location.

Species Selection

Shading characteristics of vegetation is a function of vegetative heights at maturity, the spread of the canopy, the growth rate, the duration of the leaf season, and the density of the twigs and branches during winter months.

Short species with broad crowns provide needed shade in summer and produce shorter shadows in winter. Most species have a relatively predictable mature height and canopy spread.

Ideally, for best solar exposure "leaf-out" - the growth of new leaves in spring would correspond with the end of the heating season and leaf drop would correspond with the start of the heating season. However, during the fall months there can be considerable overlap between the arrival of cold weather and complete leaf fall. There are several factors that can affect leaf-fall within species, including:



Variations in bare twig density on solar penetration

- watering and feeding practices - extended irrigation and late summer fertilizing can boost late growth and slow leaf-fall. Conversely, stopping irrigation in mid-summer can force early leaf fall.
- pruning - unpruned trees generally lose their leaves before pruned ones do.
- wind - sheltering trees from wind encourages leaf retention, where sheltered trees may delay their leaf fall two or three weeks compared to similar trees in windy locations.

Bare winter branches of deciduous trees can block sunlight to a certain extent, depending upon the species, pruning and maturity. Studies have shown that reduction in available insolation of 30-80% can be evidenced.

The Location of Vegetation

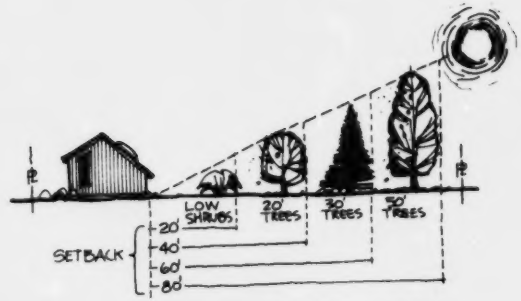
Large trees should be planted either to the north of buildings or to the south of areas that will not be the locations for solar collectors or play areas, such as south of roads or parking areas. Trees should be planted as a gradiant with taller trees to the south. Buildings should be sited directly to the east or west of trees. If the tree has a high crown, sitting close to the south of the house is best.

Trees should be planted in groups to assure maximum solar exposure. Trees in groups cast overlapping shadows creating less total shaded area than does the same number of separated trees.

Taller trees should be planted on the south side of streets rather than on the north. The width of the street and the setbacks act as a buffer to prevent the taller trees' shadows from reaching the south facade of buildings.

The closer trees are to the south wall of a building, the shorter they must be with low shrub like trees or hedges planted near the building and taller trees farther away.

Evergreen trees should be limited to the north side of buildings because they shade all year round.



Plantings on south lots

APPENDIX 1

ALBERTA CLIMATE DATA

Appendix 1 of Climatic Design and Data contains data for eleven weather stations in Alberta:

1. Calgary
2. Cold Lake
3. Coronation
4. Edmonton
5. Fort McMurray
6. Grande Prairie
7. Lethbridge
8. Medicine Hat
9. Rocky Mountain House
10. Vermilion
11. Whitecourt

The location of these weather stations is shown on the key map.

Climate information is displayed on both table and chart form for the following topics:

A. Dry Bulb Temperature Range

A.1 The mean daily temperature range in degrees centigrade, on average, by month and for the year

A.2 The mean daily maximum temperature in degrees centigrade, on average, by month and for the year

A.3 The mean daily minimum temperature in degrees centigrade, on average, by month and for the year

A.4 The extreme maximum temperature in degrees centigrade, on average, by month and for the year

A.5 The extreme minimum temperature in degrees centigrade, on average, by month and for the year

B. Degree Days

B.1. Heating degree days, from an 18 degree centigrade base, on average, by month and for the year

B.2 Cooling degree days, from an 18 degree centigrade base, on average, by month and for the year

C. Wind Speed and Direction

D.1 Predominant wind velocity in km/hr. and direction, on average, by month and for the year

Dry Bulb Temperature Range

The normal of a climate element is defined as the arithmetic mean of the observed values of that element over a specific period of time. The true mean, that is, the mean of all possible observations, can never be known exactly, but must be estimated from some sample of the past record. The normals presented here are estimates of the true mean obtained in the 30-year sample record, 1951 to 1980.

Temperatures are expressed in degrees Celsius. The "daily maximum" temperature for any month is the mean of all daily maximum temperatures recorded in that particular month. The normal is an average of the set of 30 monthly means. The "daily minimum" temperature is similarly derived from all daily minimum temperatures. The "daily" temperature is the average of the mean daily maximum and minimum temperatures. The annual mean temperature is obtained by averaging the 12 monthly values.

Standard deviations of the monthly and annual mean daily temperatures (°C) are calculated from the same data used to calculate the mean daily temperature. It is a measure of the year-to-year variability.

The temperature extremes are the highest maximum and lowest minimum values observed during the entire period of record at each station up to and including 1980.

Information Source:

Environment Canada, Atmospheric Environment Service, **Canadian Climate Normals 1955 - 1980**, Volume 2, Temperature, 1982.

Dry Bulb Temperature Range

Mean Daily Temp.
(°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Calgary	-11.8	-7.3	-4.0	3.3	9.4	13.5	16.4	15.2	10.6	5.5	-2.7	-7.8	3.4
Cold Lake	-19.0	-13.6	-7.6	2.9	10.4	14.5	16.9	15.5	9.8	4.5	-6.2	-14.2	1.2
Coronation	-16.5	-11.7	-7.1	3.0	10.3	14.4	17.3	16.1	10.5	4.8	-4.9	-11.8	2.0
Edmonton	-15.0	-9.6	-5.0	4.2	11.3	15.1	17.4	16.2	11.0	5.8	-3.7	-10.4	3.1
Fort McMurray	-21.8	-15.4	-9.2	2.1	9.7	14.0	16.4	14.8	9.0	3.3	-8.2	-17.0	-0.2
Grande Prairie	-17.7	-12.1	-7.2	2.7	10.0	13.7	15.9	14.8	9.8	4.2	-6.0	-13.4	1.2
Lethbridge	-10.3	-5.4	-2.1	4.9	11.0	15.4	18.6	17.6	12.7	7.5	-0.8	-5.8	5.3
Medicine Hat	-12.6	-7.7	-2.8	5.6	12.3	16.6	19.9	18.9	13.2	7.4	-1.6	-7.6	5.1
Rocky Mountain House	-13.0	-7.4	-4.6	3.0	9.2	12.8	15.3	14.3	9.7	4.9	-3.6	-9.1	2.6
Vermilion	-18.4	-13.3	-8.2	2.9	10.3	14.1	16.5	15.2	9.9	4.4	-6.0	-13.6	1.2
Whitecourt	-16.6	-10.2	-5.9	2.7	9.2	12.7	15.1	13.9	8.9	3.4	-6.3	-13.1	1.2

Mean Daily Maximum
(°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Calgary	-6.0	-1.5	1.7	9.4	16.0	19.9	23.3	22.1	17.4	12.3	3.3	-1.8	9.7
Cold Lake	-14.0	-7.9	-1.7	8.7	16.9	20.6	22.9	21.3	15.4	9.8	-1.9	-9.6	6.7
Coronation	-11.6	-6.6	-2.0	8.8	16.9	20.9	24.0	22.9	17.0	11.2	0.2	-6.9	7.9
Edmonton	-10.7	-4.8	0.3	9.6	17.2	20.7	23.0	21.6	16.5	11.1	0.4	-6.2	8.2
Fort McMurray	-16.5	-9.0	-2.2	8.7	16.9	21.0	23.1	21.4	14.8	8.6	3.5	-12.2	5.9
Grande Prairie	-12.4	-6.5	-1.5	8.4	16.4	19.9	22.1	21.1	15.9	9.9	-1.1	-8.2	7.0
Lethbridge	-4.5	0.3	3.9	11.2	17.7	22.0	26.1	24.9	19.7	14.1	5.0	0.0	11.7
Medicine Hat	-7.0	-2.1	3.0	12.1	19.1	23.3	27.3	26.5	20.4	14.4	4.4	-2.0	11.6
Rocky Mountain House	-7.4	-1.1	1.4	9.2	15.9	19.2	22.0	21.0	16.5	11.6	1.9	-3.5	8.9
Vermilion	-13.1	-7.5	-2.5	9.0	17.5	20.8	23.2	22.0	16.3	10.7	-1.0	-8.5	7.2
Whitecourt	-10.8	-3.3	0.8	9.7	16.7	19.9	22.2	20.8	15.8	10.0	-0.8	-7.7	7.8

Mean Daily Minimum (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Calgary	-17.6	-12.9	-9.6	-2.9	2.8	7.0	9.4	8.3	3.8	-1.3	-8.6	13.8	-3.0
Cold Lake	-23.9	-19.3	-13.5	-2.9	3.8	8.4	10.9	9.6	4.2	-0.9	-10.5	-18.8	-4.4
Coronation	-21.3	-16.8	-12.1	-2.9	3.5	8.0	10.5	9.2	4.0	-1.7	-10.1	-16.8	-3.9
Edmonton	-19.2	-14.3	-9.7	-1.2	5.4	9.5	11.8	10.7	5.6	0.4	-7.8	-14.5	-1.9
Fort McMurray	-27.1	-21.8	-16.1	-4.5	2.4	7.0	9.5	8.0	3.1	-2.0	-12.7	-21.7	-6.3
Grande Prairie	-23.0	-17.7	-12.9	-3.1	3.6	7.5	9.7	8.4	3.7	-1.6	-10.8	-18.6	-4.6
Lethbridge	-16.0	-11.0	-8.1	-1.4	4.3	8.8	11.0	10.1	5.6	0.8	-6.5	-11.4	-1.2
Medicine Hat	-18.3	-13.3	-8.6	-0.9	5.4	9.8	12.4	11.2	5.9	0.4	-7.5	-13.1	-1.4
Rocky Mountain House	-18.5	-13.6	-10.5	-3.2	2.5	6.3	8.6	7.6	3.0	-1.7	-9.1	-14.7	-3.6
Vermilion	-23.6	-19.0	-13.9	-3.2	3.1	7.4	9.8	8.5	3.4	-2.0	-10.9	-18.6	-4.9
Whitecourt	-22.3	-16.9	-12.6	-4.4	1.6	5.5	7.9	7.0	2.0	-3.4	-11.7	-18.5	-5.5

Extreme Maximum (°C)

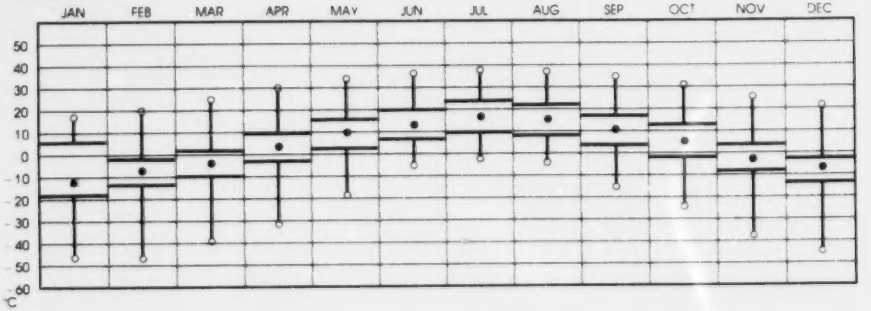
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Calgary	16.0	18.9	22.8	29.4	32.2	35.0	36.1	35.6	33.3	29.4	22.8	19.4	36.1
Cold Lake	10.6	11.7	16.7	29.4	31.7	35.6	36.1	32.8	32.8	27.4	18.9	10.0	36.1
Coronation	8.3	10.6	19.4	30.5	31.7	35.6	36.1	37.8	35.0	29.1	20.6	11.1	37.8
Edmonton	11.7	13.4	20.6	31.1	30.6	34.4	34.4	33.3	33.9	28.3	21.7	16.1	34.4
Fort McMurray	10.6	15.0	18.9	30.2	32.8	36.1	35.6	33.3	30.6	28.4	18.9	10.0	36.1
Grande Prairie	11.1	11.7	16.1	29.2	31.1	33.3	33.3	34.4	31.1	28.9	22.2	13.3	34.4
Lethbridge	16.7	18.9	23.3	31.1	32.8	38.3	39.4	38.3	36.7	31.7	22.8	18.3	39.4
Medicine Hat	18.9	18.3	28.9	35.6	37.2	41.7	42.2	41.1	37.8	33.9	24.4	20.0	42.2
Rocky Mountain House	15.0	16.1	21.7	27.8	30.6	32.2	33.3	32.2	32.8	29.4	23.3	16.1	33.3
Vermilion	11.1	11.1	16.1	31.0	32.8	34.4	37.2	36.7	33.9	28.0	20.6	10.6	37.2
Whitecourt	15.0	16.7	18.9	30.0	31.7	33.3	33.9	33.3	30.6	27.8	22.2	13.3	33.9

Extreme Minimum
(°C)

Calgary	-44.4	-45.0	-37.2	-30.0	-16.7	-3.3	-0.6	-2.2	-13.3	-22.2	-35.0	-42.8	-45.0
Cold Lake	-48.3	-42.8	-41.1	-34.4	-7.8	-3.3	0.0	-0.5	-9.4	-15.6	-36.7	-42.8	-48.3
Coronation	-44.4	-41.1	-35.6	-27.8	-13.9	-2.2	2.2	-0.2	-13.3	-21.7	-33.3	-43.6	-44.4
Edmonton	-44.4	-46.1	-36.1	-25.6	-12.2	-1.1	0.6	0.6	-11.7	-25.0	-32.8	-48.3	-48.3
Fort McMurray	-50.0	-50.6	-44.4	-35.0	-13.3	-4.4	-3.3	-2.8	-15.6	-22.8	-37.8	-47.2	-50.6
Grande Prairie	-52.2	-48.3	-42.8	-35.6	-7.8	-1.7	0.6	-2.8	-10.6	-31.7	-40.6	-44.4	-52.2
Lethbridge	-42.8	-42.2	-37.8	-25.6	-11.7	-1.7	1.7	0.0	-9.4	-21.7	-33.9	-42.8	-42.8
Medicine Hat	-46.1	-46.1	-38.9	-26.7	-11.1	-1.1	2.2	-0.6	-12.8	-23.3	-37.8	-45.6	-46.1
Rocky Mountain House	-43.9	-37.8	-38.9	-33.9	-15.6	-5.0	0.0	-2.2	-9.4	-21.1	-34.4	-42.9	-43.9
Vermilion	-50.6	-47.8	-40.0	-30.6	-13.9	-3.3	-1.1	-3.9	-12.2	-22.8	-36.1	-45.6	-50.6
Whitecourt	-50.0	-47.8	-41.7	-37.2	-12.2	-3.3	-3.3	-3.9	-18.3	-25.6	-38.3	-43.4	-50.0

CALGARY

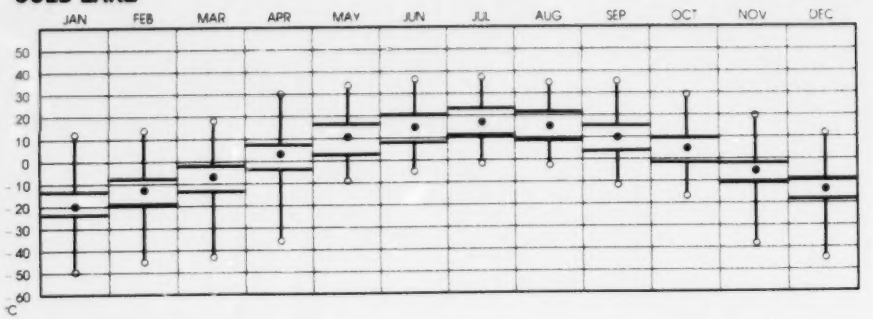
Dry Bulb Temperature Range



extreme maximum
mean daily maximum
mean daily
mean daily minimum
extreme minimum

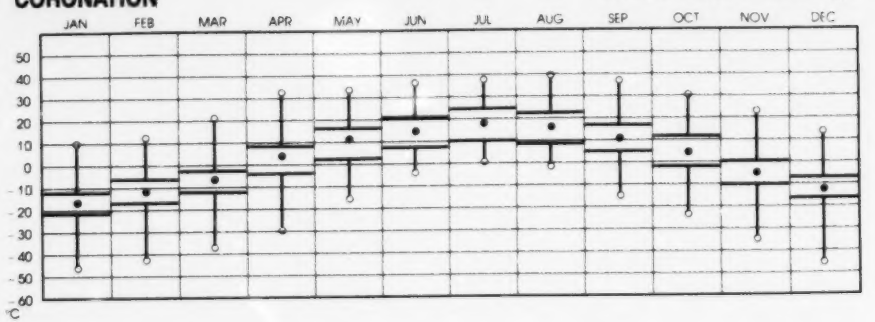
COLD LAKE

Dry Bulb Temperature Range



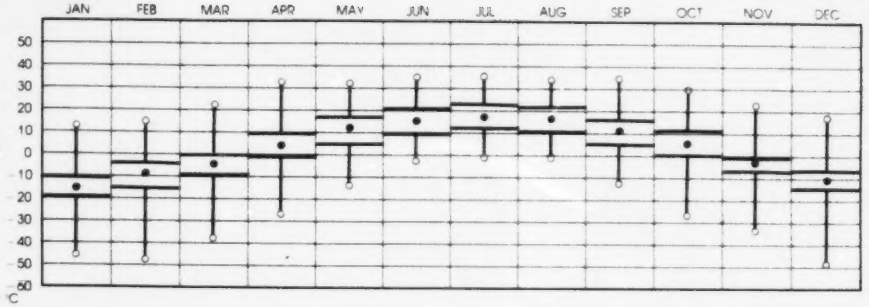
CORONATION

Dry Bulb Temperature Range



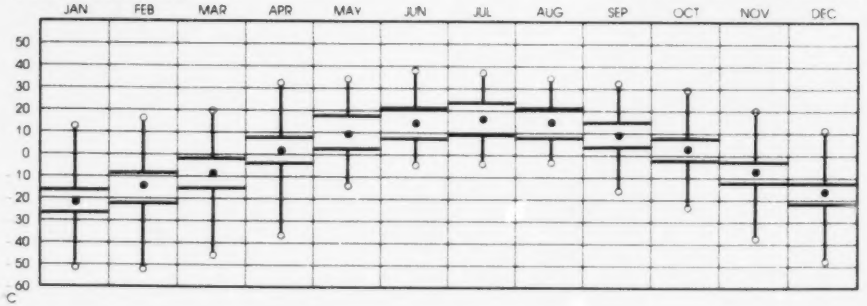
EDMONTON

Dry Bulb Temperature Range



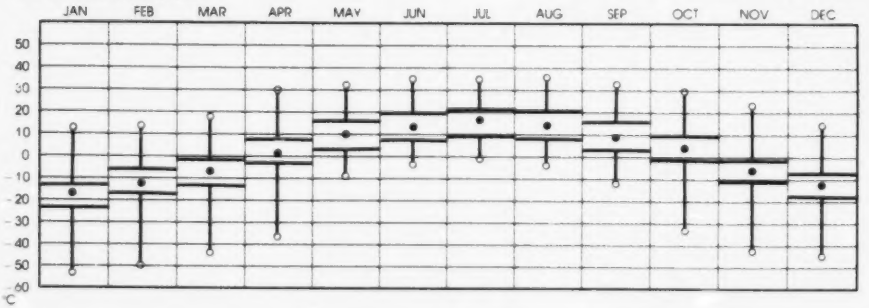
FORT McMURRAY

Dry Bulb Temperature Range



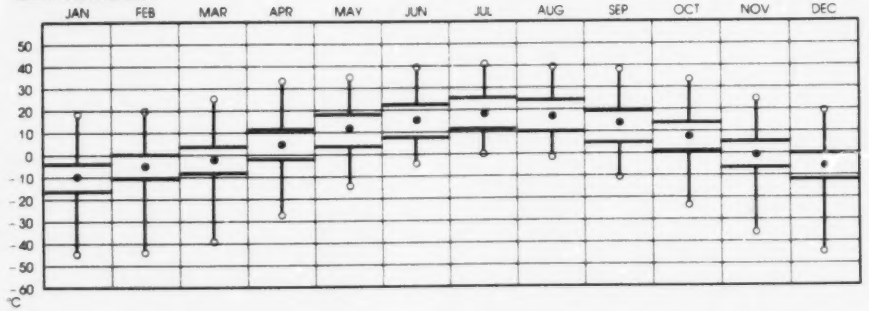
GRANDE PRAIRIE

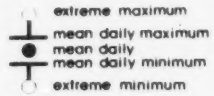
Dry Bulb Temperature Range



LETHBRIDGE

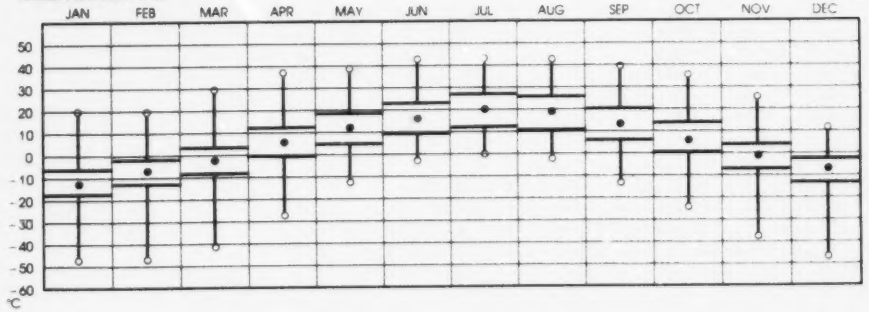
Dry Bulb Temperature Range





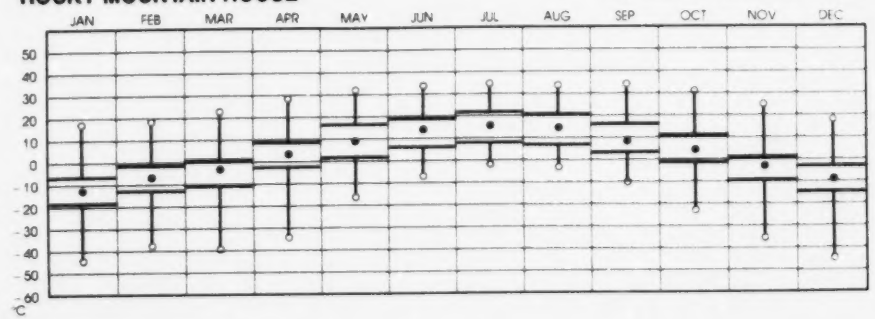
MEDICINE HAT

Dry Bulb Temperature Range



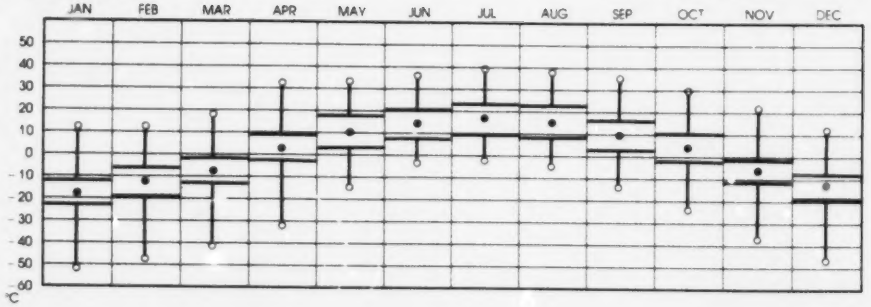
ROCKY MOUNTAIN HOUSE

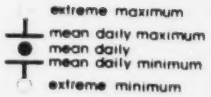
Dry Bulb Temperature Range



VERMILION

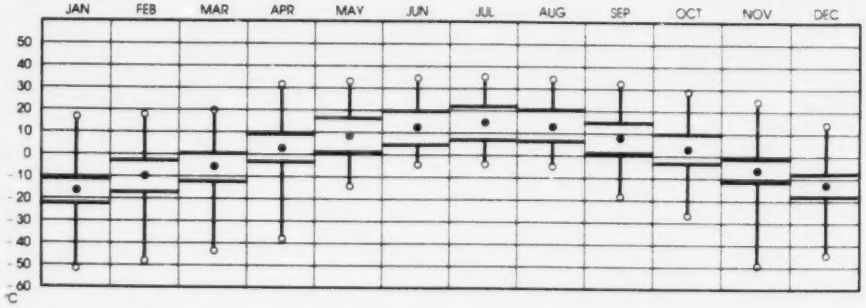
Dry Bulb Temperature Range





WHITECOURT

Dry Bulb Temperature Range



Degree Days

A degree day is defined as a measure of the departure of temperature for a day from some reference temperature. They are expressed in degrees of temperature. Various reference temperatures are used for different purposes. For example, negative departures from 18°C may be used for residential space heating and positive departures from 18°C for air conditioning requirements. These departures are computed for the day and totalled for periods of weeks, months and seasons.

HEATING DEGREE DAYS

The best known degree day is the heating degree-day below 18°C. The consumption of fuel in most homes and buildings is reasonably well correlated with mean outside air temperature below 18°C. For every additional heating degree-day more fuel is needed to maintain comfortable indoor temperatures, such that a day with 30 heating degree-days would require three times as much fuel as a day with 10 degree-days, assuming similar meteorological conditions such as wind speed and cloudiness.

COOLING DEGREE DAYS

The cooling degree-day can be used as a measure of residential air conditioning requirements during warm months. The energy required for cooling the indoor air is roughly proportional to the temperature departure above some base, commonly taken as 18°C. Of course, other external and internal factors do influence the required energy. In particular, atmospheric moisture is important since people may feel uncomfortable when outside temperature and humidity are high.

The use of 18°C for either heating or cooling degree-days does not allow for any period of "free-energy" when neither heating nor air conditioning systems are required. Consequently, a different threshold value is sometimes used. For example, a temperature base of 24°C has been used for extreme cooling degree-days or as an index of potential heat stress.

Information Source:

Environment Canada, Atmospheric Environment Service, **Canadian Climate Normals 1951 - 1980**, Volume 4, Degree Days, 1982.

Degree Days

Heating Degree-Days
(Base: 18°C)

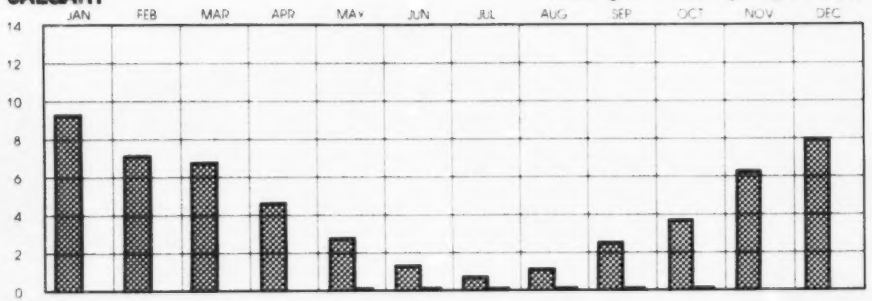
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Calgary	922.9	713.6	681.6	441.5	265.8	141.7	68.8	98.5	223.8	386.6	620.3	799.9	5365.0
Cold Lake	1135.7	892.1	793.9	453.4	238.2	111.5	55.7	91.6	246.5	418.2	726.1	1002.6	6165.5
Coronation	1067.9	839.3	777.3	451.4	240.9	116.9	52.4	83.2	225.3	410.8	687.8	925.3	5878.5
Edmonton	1021.5	779.7	713.7	413.4	209.1	98.7	48.7	78.0	210.4	379.9	650.6	880.0	5483.7
Fort McMurray	1233.9	944.4	842.1	476.6	258.7	126.6	68.4	111.3	271.9	457.6	784.5	1085.3	6661.3
Grande Prairie	1108.3	851.2	781.5	459.5	248.7	131.1	78.4	108.7	245.8	430.0	719.4	973.6	6136.2
Lethbridge	876.8	661.2	622.8	392.6	219.2	95.0	32.3	52.7	166.9	327.2	563.3	735.2	4745.2
Medicine Hat	949.5	726.7	644.9	370.9	183.3	71.4	19.5	36.5	155.1	329.5	587.5	793.5	4868.3
Rocky Mountain House	960.7	716.9	699.5	449.9	273.2	159.4	91.5	120.3	248.1	405.0	647.8	840.4	5612.7
Vermilion	1128.2	883.3	812.2	452.7	237.9	122.9	63.4	97.3	245.0	424.5	720.6	979.5	6167.5
Whitecourt	1071.7	795.0	741.2	460.0	272.9	159.8	98.1	131.9	273.3	454.2	728.4	964.3	6150.8

Cooling Degree-Days
(Base: 18°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Calgary	–	–	–	–	0.4	5.1	18.2	12.7	1.5	0.2	–	–	38.1
Cold Lake	–	–	–	0.2	1.6	7.6	22.6	13.7	0.4	–	–	–	46.1
Coronation	–	–	–	–	0.8	9.8	29.1	23.6	1.8	–	–	–	65.1
Edmonton	–	–	–	0.3	2.8	12.2	31.5	21.1	1.7	0.1	–	–	69.7
Fort McMurray	–	–	–	0.2	1.1	6.9	17.2	10.7	0.3	–	–	–	36.4
Grande Prairie	–	–	–	–	1.0	3.4	13.3	8.2	0.3	–	–	–	26.2
Lethbridge	–	–	–	–	2.2	16.4	50.5	39.0	6.9	0.7	–	–	115.7
Medicine Hat	–	–	–	0.5	6.3	27.8	77.6	63.7	10.7	0.4	–	–	187.0
Rocky Mountain House	–	–	–	–	0.2	2.5	9.1	6.1	0.6	–	–	–	18.5
Vermilion	–	–	–	0.2	0.7	6.4	17.9	11.8	0.4	0.1	–	–	37.5
Whitecourt	–	–	–	–	0.2	2.0	7.8	4.9	–	–	–	–	14.9

CALGARY

Heating and Cooling Degree Days

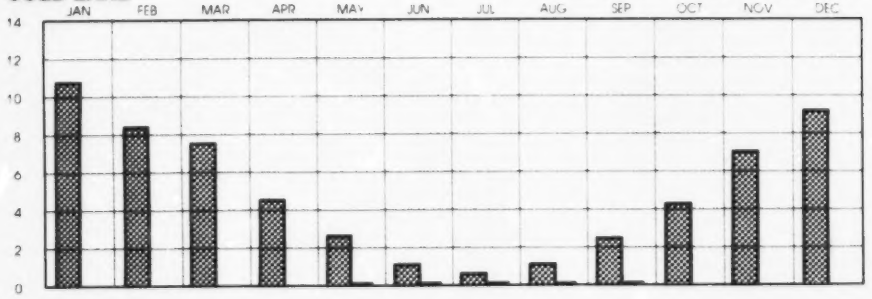


Degree Days (x 100)
(Base : 18 C)

heating degree days
cooling degree days

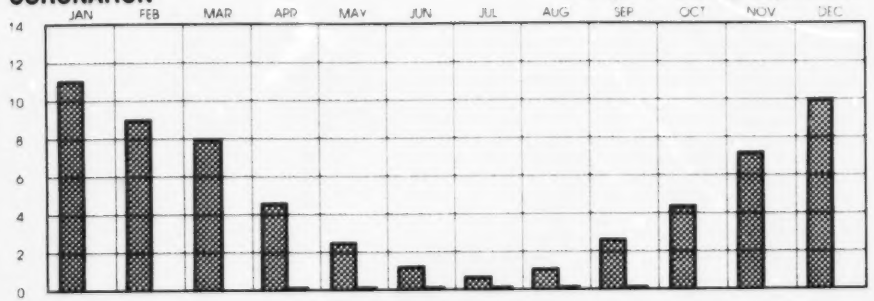
COLD LAKE

Heating and Cooling Degree Days

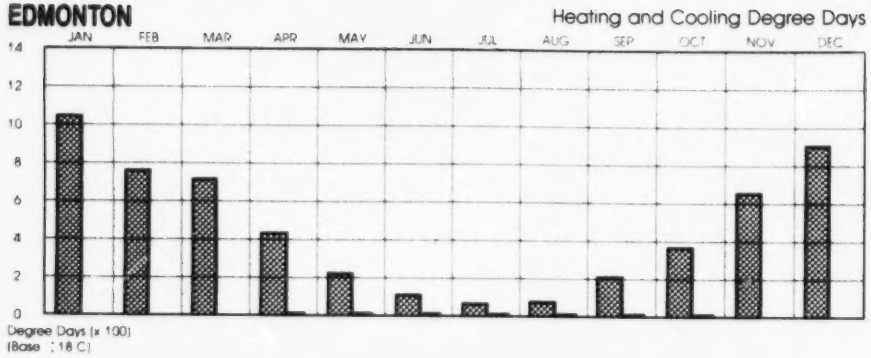


CORONATION

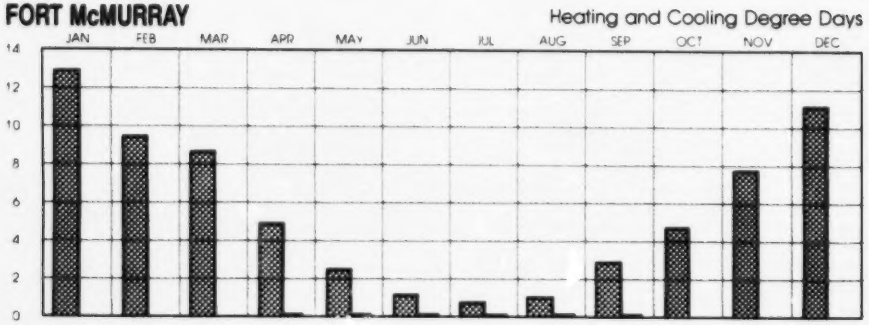
Heating and Cooling Degree Days



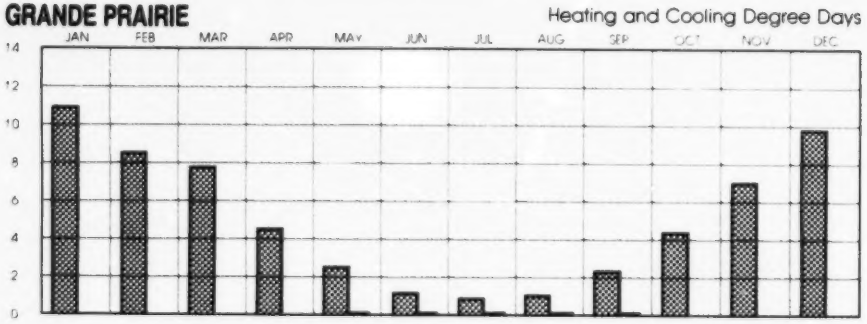
EDMONTON



FORT McMURRAY

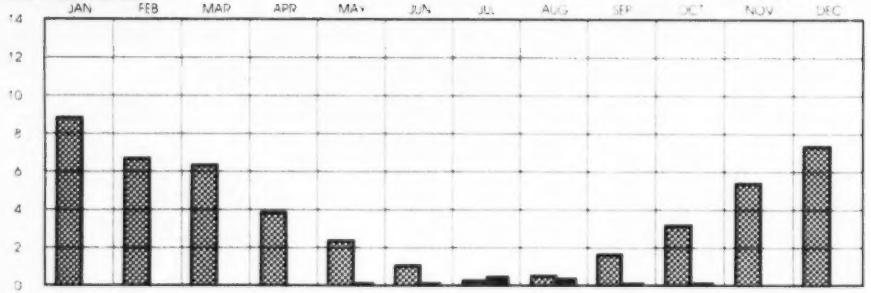


GRANDE PRAIRIE



LETHBRIDGE

Heating and Cooling Degree Days

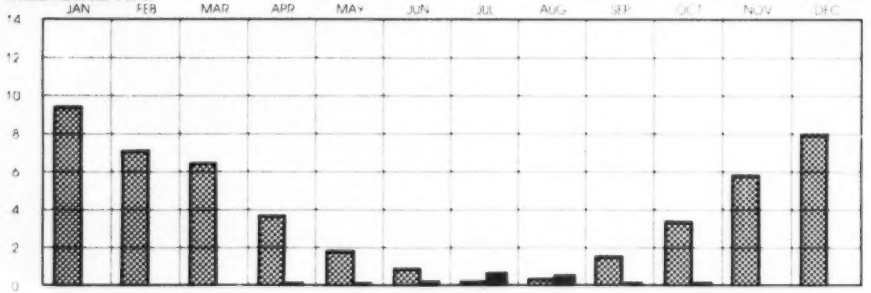


Degree Days (x 100)
(Base : 18 C)

heating degree days
cooling degree days

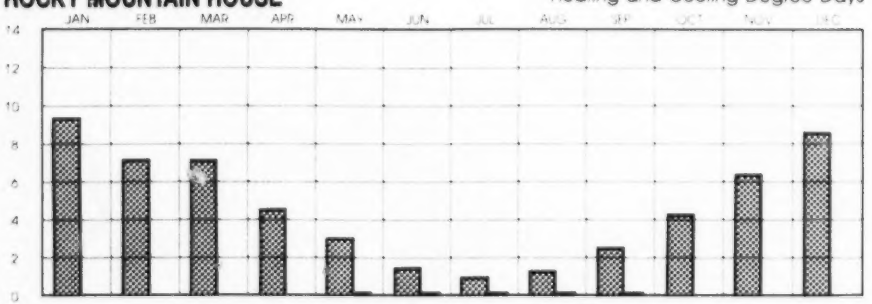
MEDICINE HAT

Heating and Cooling Degree Days



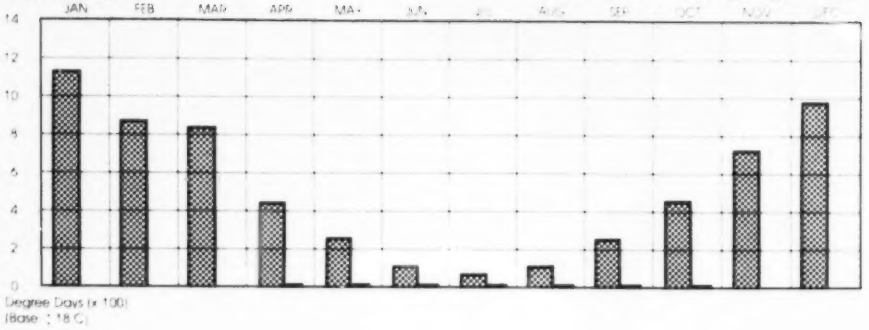
ROCKY MOUNTAIN HOUSE

Heating and Cooling Degree Days



VERMILION

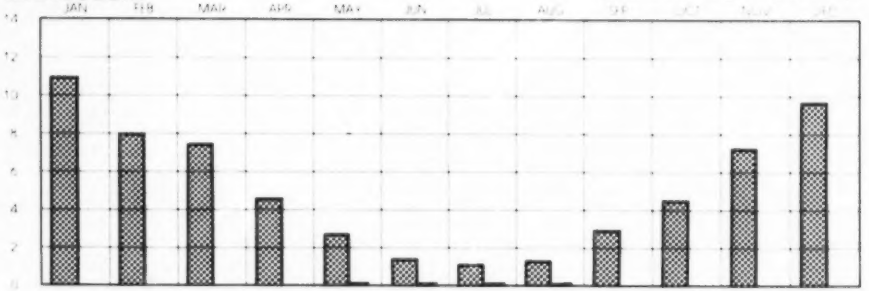
Heating and Cooling Degree Days



Degree Days (x 100)
(Base 18°C)

WHITECOURT

Heating and Cooling Degree Days



Wind Speed and Direction

Wind speed is the speed of air at a given point and is expressed in kilometres per hour. Wind direction is the direction from which the wind blows and is expressed in true rather than magnetic direction.

Data presented in the following table has been summarized from the 16 and 8 point wind tables. The monthly and annual values of mean wind speed were calculated without regard to direction.

The prevailing direction given is the most frequent or modal direction (ie. highest percentage frequency).

Information Source:

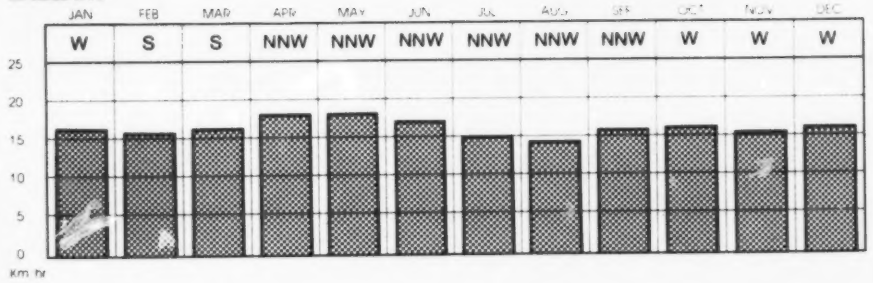
Environment Canada. Atmospheric Environment Service. **Canadian Climate Normals 1951 - 1980.** Volume 5. Wind. 1982.

Wind Speed (km/h) and Direction

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Calgary	16.2	15.8	16.4	18.1	18.2	17.0	14.9	14.4	15.8	16.3	15.4	16.1	16.2
	W	S	S	NNW	NNW	NNW	NNW	NNW	NNW	W	W	W	W
Cold Lake	11.9	11.9	12.9	14.8	15.7	14.4	13.5	12.7	14.2	14.5	13.3	12.0	13.5
	W	E	E	E	E	W	W	W	W	W	W	W	W
Coronation	16.3	15.7	15.7	16.5	16.9	16.0	14.7	14.5	16.1	16.4	15.9	16.1	15.9
	NNW	NNW	NNW	NNW	NNW	NW	NW	NW	NNW	S	S	NW	NNW
Edmonton	13.0	13.0	13.8	15.5	16.1	15.4	14.0	13.4	14.6	14.3	13.5	13.0	14.1
	S	S	S	S	S	WNW	WNW	S	S	S	S	S	S
Fort McMurray	8.6	9.1	9.9	11.2	11.4	9.8	9.2	8.9	9.6	10.6	9.3	8.4	9.7
	E	E	E	ESE	E	E	W	SW	W	E	E	E	E
Grande Prairie	11.5	12.3	12.8	14.5	16.8	16.2	14.1	13.6	13.7	14.4	12.0	11.3	13.6
	NW	NW	NW	W	W	W	W	W	W	W	W	NW	W
Lethbridge	21.2	21.1	21.0	21.3	20.4	20.0	16.9	16.8	18.4	22.5	22.4	23.1	20.4
	W	W	W	W	W	W	W	W	W	W	W	W	W
Medicine Hat	15.3	15.2	16.2	18.1	17.3	16.1	14.4	14.5	15.7	17.3	16.7	16.8	16.1
	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Rocky Mountain House	8.2	8.5	9.4	10.5	10.8	9.5	8.6	8.1	8.2	8.9	8.2	8.1	8.9
	NNW	ESE	ESE	ESE	NW	NNW	NNW	NW	NW	SE	NNW	NNW	NNW
Vermilion	12.2	12.3	12.9	14.8	15.5	14.2	12.5	12.0	13.4	13.9	13.1	12.3	13.3
	W	W	SE	SE	SE	W	W	W	W	W	W	W	W
Whitecourt	9.6	9.5	10.1	10.5	11.2	10.4	9.3	8.5	9.1	9.2	8.8	8.8	9.6
	W	W	E	E	WNW	W	W	W	W	W	W	W	W

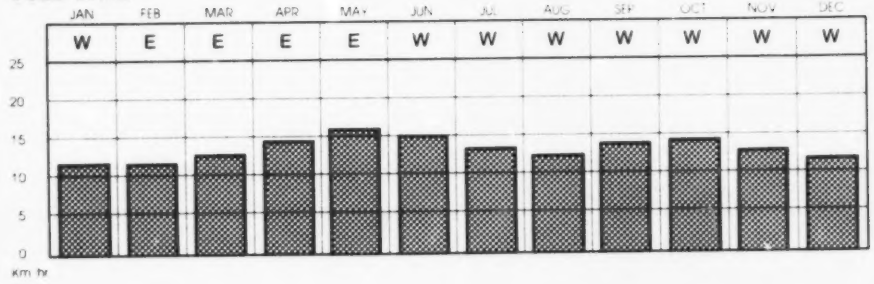
CALGARY

Wind



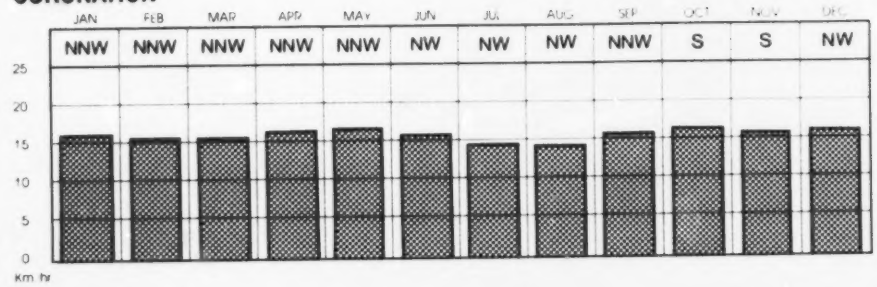
COLD LAKE

Wind



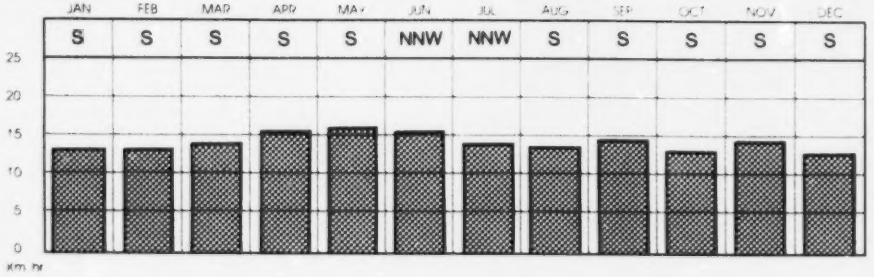
CORONATION

Wind



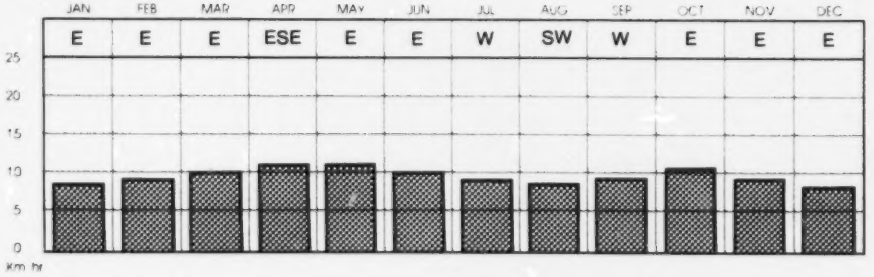
EDMONTON

Wind



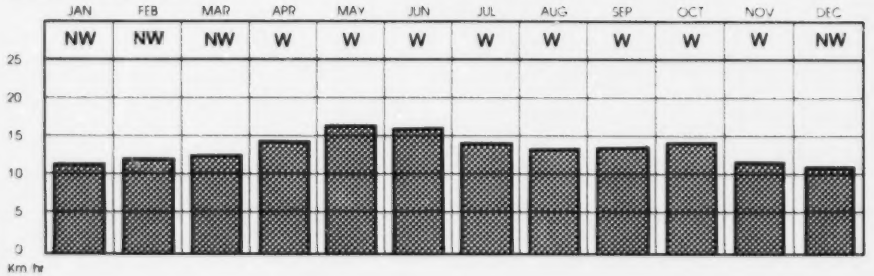
FORT McMURRAY

Wind

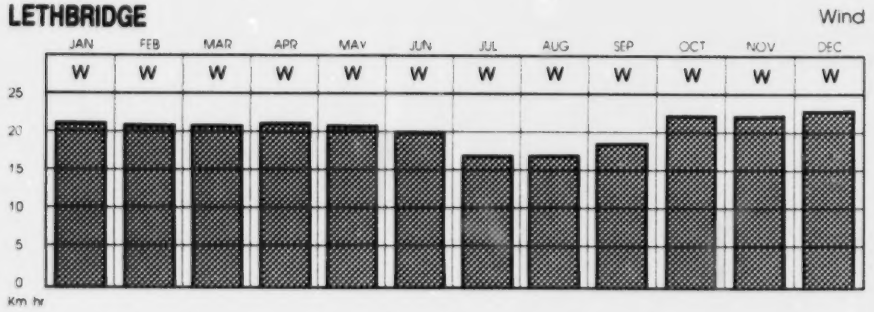


GRANDE PRAIRIE

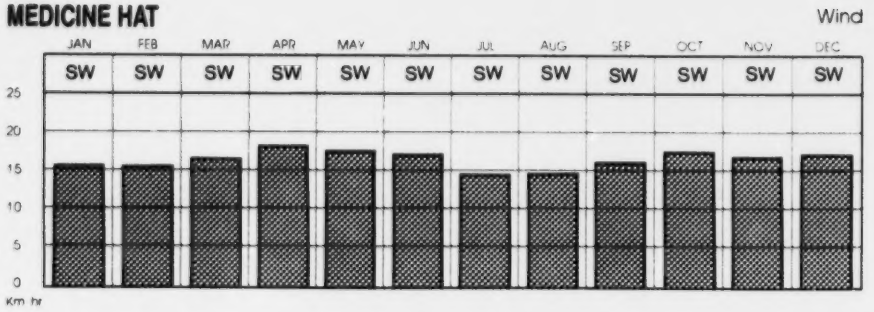
Wind



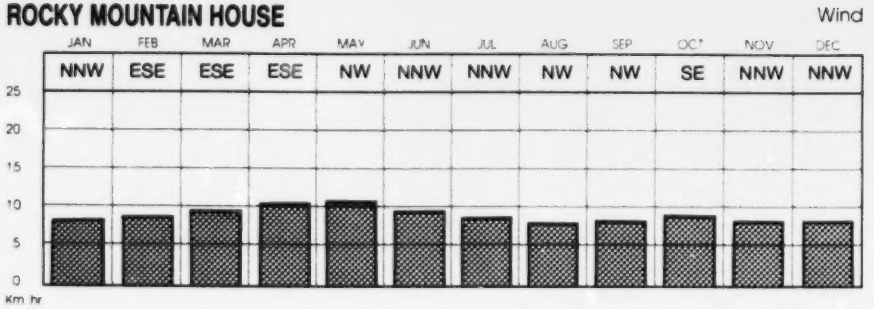
LETHBRIDGE



MEDICINE HAT

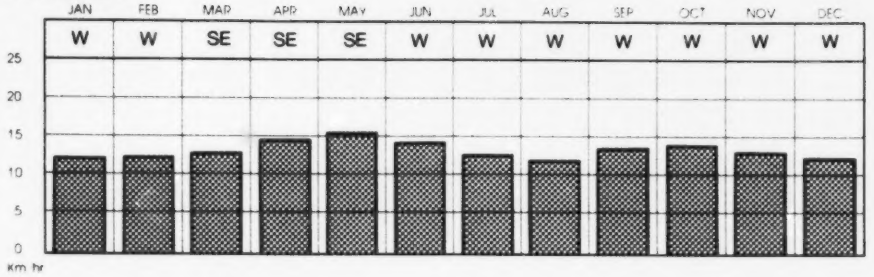


ROCKY MOUNTAIN HOUSE



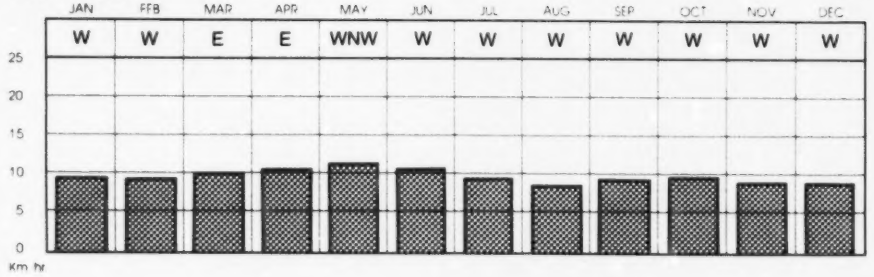
VERMILION

Wind



WHITECOURT

Wind



APPENDIX 2

PROCEDURE TO PREPARE A TOPOCLIMATIC SITE MAP

The preparation of a topo-climatic map is a necessary first step in both the site design and evaluation process. The purpose of a topo-climatic map is to graphically display the climatic characteristics of a given site. This in turn would serve as the reference map on which the principles of energy efficient site design can be applied. Because all relevant climatic information is displayed on a single map, potential conflicts and the magnitude of these conflicts are immediately identifiable.

STEP 1 Assemble the Data

1.1 This analysis uses a topographic map of a site as its base. On this map land contours, water bodies and existing tree stands should be indicated.

1.2 Climate data for various regions in Alberta has been furnished in this resource package.

1.3 The climate information is presented by topic. The following topics are included:

a. **Dry Bulb Temperature Range:** showing the average extreme maximum and minimum temperatures by month and for the year;

b. **Degree Days:** heating and cooling degree days determined from a base of 18 degrees centigrade;

c. **Wind Speed and Direction:** predominate wind speed and direction during an average month.

Review the climate date for your region. Pay special attention to c. Wind Speed and Direction.

STEP 2 Display Topographical and Climatic Information

2.1 Climate conditions and physical characteristics of a site which will influence energy usage are:
The Orientation of Slopes: south, southeast and southwest slopes can provide good solar exposure;
The Direction and Velocity of Winter Winds: cold air, driven by winter winds, can accelerate and increase heat loss and therefore increase the space heating load;
The Direction and Velocity of Summer Breezes: summer breezes provide an opportunity for using natural ventilation as a substitute for air conditioning;
Exposed Areas: ridges or high areas that have little or no protection from winter winds;
Cold Air Flow: natural channels for the movement of cold air through a site such as gulleys or openings in vegetation; and the route for downhill night-time cold air flow;
Cold Air or Frost Pockets: low lying areas without good outlets for cold air to flow; and
Water Bodies: ponds or streams.

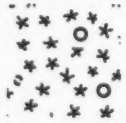
2.2 Graphic symbols can be used to represent these characteristics. Suggested symbols to use are:

WINTER WINDS

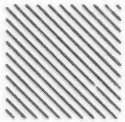
COLD AIR FLOW

RIDGES OR HIGH AREAS EXPOSED TO WINTER WINDS

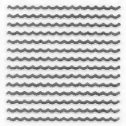
SUMMER BREEZES



COLD AIR OR FROST POCKETS



SOUTH, SOUTHEAST, SOUTHWEST FACING SLOPES



WATER BODIES

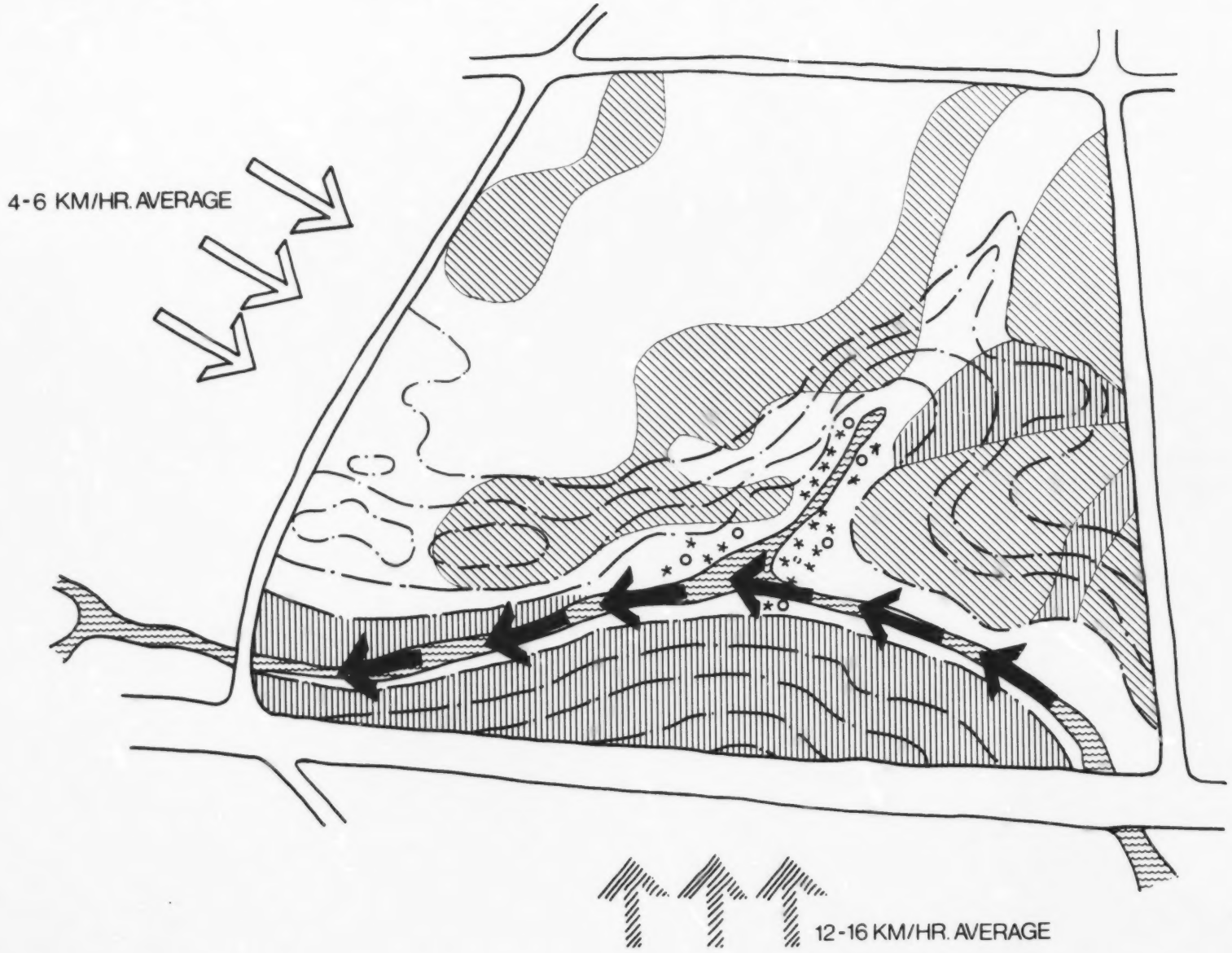
STEP 3 Apply the Topoclimatic Information

3.1 Each of the climatic and physical characteristics should be displayed on the base map. Greater clarity can be achieved if color is used in addition to the symbols.

3.2 **Application for Evaluation**
If the material in this kit is being used to review a proposed site plan, then it may be convenient if the topoclimatic information is displayed on a transparency so that it can be overlayed on the proposed site plan.

3.3 **Application for Design**
If the material in this kit is being used to aid in the process of site design, then the topoclimatic information can be recorded on a separate map that can be readily used for reference.

Topo-Climatic Map — an example



ACKNOWLEDGEMENTS

This kit is the result of a collaborative process involving many people and agencies. The input and advice from a number of energy professionals and land use planners are greatly appreciated. Any omissions or errors, however, are the sole responsibility of the Project Team.

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FIELD TESTING AND REVIEW

A number of events were used to generate and test ideas for the development of this kit. These events included the design of a pilot energy subdivision in Hanna (August to October 1983); two simulation workshops (September 29 and 30, 1983, and July 26, 1984); and the referral of the various draft documents to land use planners for comments throughout the process.

The contribution of the following agencies and people is hereby acknowledged:

Alberta Housing Corporation: Gordon Grant
Alberta Municipal Affairs; Planning Branch: Carol Ames, Ron Denboer, Miles Foreman, Bruce Gunn, Al McCully, Stan Verbisky.
Battle River Regional Planning Commission: Bob Ridett
Calgary Regional Planning Commission: Carol McCleary, Lorie Pesowski
City of Edmonton: Beatrice Denboer
Edmonton Metropolitan Regional Planning Commission: Sandra Fearon, Bea Fricson
Mackenzie Regional Planning Commission: Rob Roycroft, Therese Skoczylas
Oldman River Regional Planning Commission: Lorraine Grant
Palliser Regional Planning Commission: Bill Ashton
Red Deer Regional Planning Commission: Charleen Currie
South Peace Regional Planning Commission: Frank Liszczak
Yellowhead Regional Planning Commission: Neil Connelly, Chris Walker